Aquaculture Extension Manual No. 41 July 2008

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FOREWORD

Catfish is one of the most important freshwater food fishes in Southeast Asia. Along with freshwater prawn and tilapia, catfish is a viable animal protein source among people in landlocked areas. In 2006, a total of 2,370 metric tons have been produced in the Philippines.

SEAFDEC Aquaculture Department's work on catfish includes refining technologies in aspects ranging from hatchery and broodstock development up to the grow-out phase, including the development of feed formulation optimal to catfish growth and survival.

This manual intends to provide necessary information to fish farmers interested in growing catfish. Furthermore, we hope that other stakeholders, including researchers, extension workers, fisheries technicians and members of the academe could find the information contained in this manual beneficial in their endeavors.

Let us join hands to further the aquaculture industry.

Joebert D. Toledo, D. Agr.
Chief
SEAFDEC/AQD

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INTRODUCTION

Clarias macrocephalus (Gunther), commonly known as the Asian or walking catfish, belongs to the family Clariidae and could be found in freshwater habitats such as swamps, streams, rivers, lakes, dams and canals. It is a highly valued food fish in Southeast Asia, particularly in Malaysia, Thailand, and the Philippines because of its tender and delicious meat. They are so called catfishes because they possess whisker-like structures near their mouth called barbels. The fish has arborescent organs next to its gills for breathing atmospheric air which enables it to stay longer out of the water. The fish can tolerate crowding and could be cultured at high stocking densities and requires a smaller area for farming. *C. macrocephalus* constitutes a valuable fishery for small scale fishers in the region.

In the Philippines, catfish is locally known as *hito* to Tagalogs, *paltat* to Ilocanos, *pantat* to Cebuanos and Ilonggos, and *ito* to Pampangeños. However, its natural population is fast disappearing probably due to overfishing, long dry seasons, loss of breeding habitats or pesticide poisoning. To revive the species, breeding, hatchery and nursery techniques have been developed and refined at the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD). In support to the young and growing catfish industry, *C. macroceplus* grow-out culture techniques have also been developed at SEAFDEC, and some common practices will be discussed in this manual.

Characteristics

Catfish has a grayish black color. There are ten vertical stripes of white spots on the abdomen. The occipital process of the head has a round lobe. The fish feeds at the bottom but it can be trained to take food at the surface with formulated diet, trash fish, chicken entrails, kitchen refuse, worms, stale bread, etc. Under culture conditions, *C. macrocephalus* with an initial size of 3-5 grams can reach 80-150 grams in about 3-5 months at a stocking density of 10 fish/m^2. The female matures at the age of 6 to 8 months. Catfish is also called 'walking catfish' because it uses its pectoral spines for crawling.

Figure 1. The Asian catfish *Clarias macrocephalus*

SITE SELECTION

Water supply

There should be clean, sufficient and reliable water. Water replenishment could be done whenever needed (e.g., disease outbreaks or nutrient overloading) to maintain good water quality and depth in ponds. The area should have complete protection against floods and free from agricultural, industrial and domestic pollution. Sources of water may come from streams, springs, irrigation canals, dams, etc. These sources may contain competing, miscellaneous species. In contrast, well water is free from unwanted species. It is more advantageous for the water source to move through the pond by gravity without energy input.

Figure 2. Considerations for site selection (*top to bottom*): water supply, soil, and fingerling source

Soil

Preferable types are clay, sandy clay and clay loam. Soil must have good compaction during dike construction and should hold or retain water inside the pond. Sandy, porous or loamy types are not recommended. Areas with trees and rocks will cause a lot of problems like seepage and leakages. Soil with pH ranging from 6.5 to 7.5 is deemed ideal.

Availability of fingerlings and technology

The presence of a hatchery and nursery for sufficient supply of catfish fingerlings within the locality is recommended. Available technology information and government extension services are also very helpful.

Labor, feeds and other supplies

For a small or backyard farm, family labor is enough, but in a large commercially-operated farm, available and skilled labor could be hired. Feeds, manure, lime and other supplies must be readily available for purchase.

Proximity to markets and roads

The site must be accessible by road and near the prospective buyers. Harvested fish could easily be disposed partially or in volume in the area.

Peace and order

A peaceful and orderly environment is important. The farm should not have problems with stealing or poaching of cultured stocks.

REARING SYSTEMS

Pond culture

Culture in earthen ponds is the most popular and common practice in rearing catfish. It is a land-based body of water enclosed in earthen or concrete dikes. Pond area ranges from 50 to 3,000 m^2 and about 0.7-2.0 m deep. It is provided with gates made of wood, cement or pipes. The pond bottom has a central canal with the elevation sloping toward the gate. The inner side of the dikes must be firm to prevent catfish from burrowing through and escaping. Give careful attention to pond size and design in constructing a pond. Small ponds are manageable, but cost more to construct. Ponds with larger areas can support higher biomass and feed, but have higher water requirements. Lower stocking density is advisable in large ponds. Provide grass cover on dikes to avoid muddy runoff during rainy season.

Figure 3. Catfish pond culture

Figure 4. (*Clockwise from top left*): Pond draining and levelling, repair of gates and dikes, eradication of pests, and liming

To prepare the pond:

1 Drain, level, soil-seal gates and dry pond bottom (2-3 weeks)
2 Repair gates and screens, dike leaks and seepages
3 Eradicate unwanted species using lime and 21-0-0 (5:1 ratio)
4 Install fence (20-30 cm high) made of old nets along the perimeter dike
5 Apply lime at 500-1,000 kg/ha
6 Apply cow or chicken manure at 500-1,000 kg/ha (tea bags)
7 Let water in initially at 10-20 cm depth (settle for 7 days)
8 Apply a mixture of the inorganic fertilizers ammonium phosphate (16-20-0 at 50 kg/ha) and urea (45-0-0 at 25 kg/ha)
9 Increase water depth to 50-60 cm. Plant swamp cabbage or *kangkong* (*Epomea aquatica*) and/or water hyacinth (*Eichornia crassipes*) to serve as shelter, and maintain or reduce growth to occupy only 10-20% of the area so as not to obstruct feeding activities during culture
10 Replenish 20-30% of water and stock the fish

Pond preparation is done to:

- Enhance the decomposition of organic matter and other toxic gases and compounds in the pond soil
- Get rid of predators and other unwanted species
- Prevent entrance of predators and escape of stocks
- Disinfect the pond, break the life cycle of disease-causing agents and neutralize soil pH
- Prevent water quality and disease problems
- Grow natural food organisms and fish shelter

Pen culture

Pen culture is a system fully enclosed by nets on all sides but utilizes the dug-out pond, dam or lake bed as bottom enclosure. Bottom with too much silt and decaying organic matter should be avoided. Pen enclosures could be made of nylon B-net or poly green net 2-5 mm mesh size. These are usually supported by fixed wooden or bamboo poles staked in mud at 15-30 cm depth or more, depending on the substratum. Pens may be constructed 5 x 5 x 2 m or 10 x 10 x 2 m depending on the desired size. Place swamp cabbage or water hyacinth as fish shelter.

Figure 5. Pen culture

Tank culture

Tanks that are not utilized or abandoned in old hatcheries can be used for culturing catfish. Freshwater source must be available when needed. Place soil (sandy clay, clay or clay loam) as substrates 4 inches thick in the tank bottom and compact firmly. Wash the tank soil substrates, slowly drain, then dry. Apply lime 100 g/m^2 to disinfect and neutralize soil pH. After 2 weeks, fill with water 1-1.5 m deep depending on tank capacity. Place cow manure 10-20 kg/m^3 in tea bags to fertilize and grow natural food organisms. Follow up application of inorganic fertilizer (10-20 ppm) with a mixture of urea and 16-20-0 (1:2 ratio). When water color turns light green or light brown in color, remove the manure bags and re-use later.

Stock catfish fingerlings 10-30 pcs/m^3 depending on water supply and support facilities (aeration or flow-through faucet). Catfish reach 80-110 g in 6 months with a survival rate of 80-100%. Growth and survival depends on the size and quality of fingerlings used.

Figure 6. Tank culture

Cage culture

A cage culture system is fully enclosed by nylon nets (2-5 mm mesh) on all sides and bottom similar to a bag or inverted mosquito net, supported either by ropes tied in the four corners to posts staked in the pond bottom or by rigid frames with floats. The cage is submerged and maintained at 0.7 to 1.5 m water depth in suitable areas like reservoirs, dams, lakes and dug-out ponds. Cage sizes may vary from 2 x 2 x 1.5 m to 10 x 10 x 1.5 m. Cages can be easily transferred or moved from one area to another.

Figure 7. Cage culture

Culture of catfish (10-100 pcs/m^2) in cages installed in ponds can be integrated with sex-reversed tilapia (2-3 pcs/m^2) stocked outside the cages. Stocking density depends on the water supply and support facilities. Tilapia will be dependent on the natural food partly fertilized by catfish waste. Brush the cages monthly to remove biofouling or algal growth.

Rice-fish culture

Rice-catfish farming is practiced in India, China and other Asian countries where fish and rice are the staple food. In recent years, the cultivation of high-yielding varieties of rice involving the use of pesticides has affected fish culture in paddy farms. Some farmers have attained success by using integrated pest management practices.

The paddy plot or rice pond can be renovated by excavating canals, pools or trenches to retain water, which will provide shelter to fish during hot periods or summer months. The canal may be constructed on two sides around or along the dikes, occupying about 30-40% of the area. The canal has a trapezoidal shape with a top width of 8 m, base width of 4 m, and during culture, a full canal depth of 1-2 m. The water depth on a rice paddy plot can be maintained at 10-20 cm depth. The rice paddy plots have a side sloping towards the canal or trench where the soil is compacted to make the bank strong. Dikes are utilized for growing vegetables and fruit trees. Tilapia may be cultured together with catfish in rice paddies.

Figure 8. Rice-fish culture

FACTORS TO CONSIDER

Fingerling selection

Select fingerlings that are healthy, free from disease and swim actively in groups. Avoid fingerlings with skin lesions, pale, thin, weak, swollen or discolored gills, tail rots, rotten barbels and abnormal swimming behavior. These fingerling conditions are associated with disease, handling or stress-related problems. Bigger (average body weight of 3-5 grams) and uniform-sized fingerlings usually result to higher survival and shorter culture period.

Figure 9. (*From top*) Fingerling selection, handling and transport of fingerlings

Handling and transport of fingerlings

Do not feed fingerlings 24 hours prior to transport to allow them to rest and defecate. Before stocking the fingerlings, it is recommended that they are treated with 100 ppm formalin for 5-10 minutes or dipped in 20-30 ppt saltwater for 30 seconds to rid them of parasites. Handle fish carefully during harvest, sorting and counting. Remove dirt and feces before packing. Pack the fingerlings (300-500 pcs/bag) in double-lined plastic bags (20 x 30 in) with 8-10 liters of water with oxygen. Tie bags with rubber band.

Before transporting over long distances, lower the temperature to about 20-23°C by placing 200-250 g ice surrounding the transport bags inside the styrofoam box. In plane transport, plastic bags will be further packed in styrofoam boxes and then packed again in bigger plastic bags as required by the airlines. Transport early in the morning or late in the afternoon.

Acclimation and stocking

Replenish 30-50% of the pond water before stocking to an initial depth of 50-60 cm. Increase water depth as the fish grow bigger.

Figure 10. Acclimation of fingerlings

Upon arrival, acclimatize the fingerlings by letting the plastic bags float for 10-20 minutes in pond water to allow the fish to rest and even out the temperature of the water in the plastic bags and pond. A temperature difference of 2°C or more is very stressful to catfish and leads to disease problems.

Open the bags and slowly splash a small amount of pond water with an interval of 3-5 minutes for 20-30 minutes to let the fish gradually adjust to its new environment. Avoid releasing the fish from midnight until very early morning when dissolved oxygen (DO) levels are lowest. Start feeding the next day after stocking.

Stocking density ranges from 5 to 20 pcs/m^2 depending on water supply, availability of fingerlings and support facilities of the farm. If the fish farmer has several ponds, staggered stocking is recommended at an interval of 15-30 days to program water management and harvesting. Fingerlings from different holding tanks usually have different body color depending on their environment. Avoid stocking fingerlings of different sizes and color at the same time to prevent occurrence of aggressive biting between stocks.

Feeds and feeding

Catfish are carnivorous and need a substantial amount of protein for growth. As they grow bigger, they feed on worms, insects, crustaceans, other benthic organisms, decaying protein food and organic matter on the pond bottom. In culture, catfish can feed on trash fish or chicken entrails mixed with rice bran or boiled broken rice, kitchen refuse, by-products of canning factories, and formulated diets. Stale bread can be fed to catfish, too. Install light at night to attract insects which drop inside the pond to serve as additional food.

Figure 11. Feeding of catfish

Trash fish or blanched chicken entrails are finely chopped and mixed with 10% rice bran during the first 2 months of culture, and increased to 20% from the third month until harvest. One part of cooked broken rice may be added. These combined ingredients must be mixed or ground to form a sticky paste.

Feed is given twice daily (7 AM and 5 PM) by forming the paste into small balls and given based on the feed ration or until the fish is satiated.

The feeding rate of moist diet is 10% of the biomass in the first 2 months and reduced to 8% from the third month of culture until harvest. Problems of using this type of feed include fouling, limited supply and storage. Feed conversion ratio (FCR) ranges from 5 to 6.

A formulated diet with an estimated crude protein of 34% is desirable for catfish grow-out. Feed is given in crumble form for the first two months, and in pellets (2.5 mm diameter) in the third month until harvest. Feed conversion ratio using formulated feeds ranges from 1.8 to 2.3.

Feed catfish at the same place and time daily. Check the response of the fish by throwing out a small amount of feed. If there is no response, stop feeding and check for problems. These could include oxygen deficiency, water fouling,

Table 1. Amount of feed to be given to catfish at different times after stocking

Month	Amount of feed (% of total biomass)
1	5.0
2	4.5
3	4.0
4	3.5
5	3.0

Table 2. Tested formulated diet for *C. macrocephalus* with initial mean body weight of 3.6 g and about 109 g after 120 days of culture*

Composition	%
Chilean meal	20
Defatted soybean meal	30
Bread flour	9
Soybean oil	5
Mineral mix**	1
V-22**	1
Dicalcium phosphate	3
Rice bran	31
Total	100

*Estimated nutrient content (dry matter basis) : crude protein 34%, crude fat 9.5%, crude fiber 4%, crude ash 14.2%, and nitrogen-free extract or digestible carbohydrate 36%
**Commercial pre-mix

undesirable species or predators (snakes, frogs, lizards), muddy water, temperature fluctuation or diseases. Overfeeding should be avoided to prevent water pollution, increased incidence of diseases, fish mortality and higher production costs.

Sampling

Figure 12. Catfish sampling

Sampling serves as the basis in adjusting the daily feed ration, checking fish health condition, and predicting the harvest schedule.

Before sampling, prepare all the needed materials like weighing scale, pails, scoop nets, basins, seine net, etc. Conduct sampling during the cooler part of the day, preferably in conjunction with the schedule of water replenishment. The lower water depth will make it easy to seine or catch samples. Sample fish before feeding. Weigh 30-50 catfish at once and get the average body weight by computing the total weight divided by the number of pieces sampled. Conduct sampling once or twice monthly. Frequent sampling will disturb the environment and feeding response of the fish.

Water management

During the first month of culture, water quality is not much of a problem. Change about 30 to 50% of the water volume once a week. As the fish grows bigger, daily feed requirement increases and problems occur due to high organic load. Water replenishment will be done twice a week at about 50-70% of the volume from the third month of culture until harvest.

Figure 13. Obtaining water parameters

Farm records

Recording all farm activities in a logbook is very important. Similarly, data monitoring per pond should be kept in separate folders. Data pertaining to expenses should be kept for future economic evaluation of farming operations.

Table 3. Farm records data

Technical data	pond number and area, species stocked, total stock, date of stocking, sampling or harvest, source of stock, initial average weight, stocking density, kind of feed, feeding time, feed rate, fish sampling, soil and water parameters, kind and dosages of fertilizers, water management, disease problems and prevention
Harvest data	survival rate, final average weight, production, feed conversion ratio (FCR), price per kilo
Expenses	pond inputs and their corresponding unit and total costs, transportation, electricity, harvesting, rental, taxes, hired labor and other related expenses

Harvest and marketing

Prior to harvest, collect, cook and eat catfish for taste test samples for off-flavor. If off-flavor is detected, delay harvest and determine the cause. Replenish 60-80% of pond water for 2-3 days. Hold harvested fish in vats or tanks with running water for a few days.

Harvest catfish when they reach 80-200 grams after 4-6 months culture. Do not feed the fish prior to harvest to empty their stomach content. Catfish are harvested and marketed live. Drain 50% of the pond water and harvest the fish using seine net (1 cm mesh, 2.5-3 m wide, 10-15 m long or depending on the width of the pond). Totally drain the pond and scoop the remaining fish that concentrate in the drain canal and harvesting pit. If the pond cannot be totally drained, use a water pump. Harvest fish in cages by

Figure 14. Harvest and marketing of catfish

lifting the net, scooping and hauling the fish. Harvest catfish in tanks by total draining. Transport live fish in tin cans, styrofoam boxes, plastic containers with water, or in double-lined plastic bags with oxygen. Do not keep them long in holding tanks or containers; doing so could result to reduced weight and lower market price.

Catfish are marketed live on a retail basis, wherein fish are stocked in holding boxes and displayed along highways accessible to consumers. Fish can also be sold to restaurants, supermarkets or during public market days. Selling on a wholesale basis is done through cooperatives but commands lower prices compared to retail. In some instances, catfish are sold to sports fishing resorts.

DISEASE MANAGEMENT

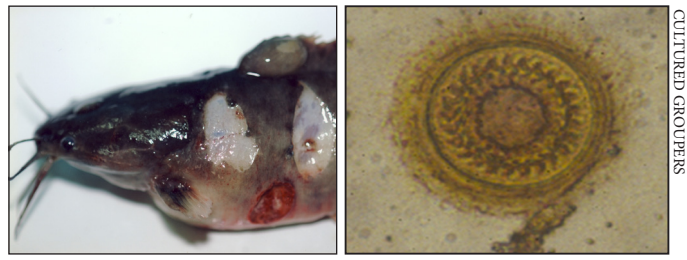
Diseases usually result from poor water quality and stress due to handling and high stocking densities. Catfish diseases could be of bacterial, fungal, viral, nutritional or environmental origin. Diseases usually occur during cooler months. In grow-out culture, mortalities of about 50% or more may occur two weeks after stocking as a result of the combined effects of these diseases.

Disease signs

- Lack of appetite or reduced feed intake
- Abnormal swimming behavior
- Discoloration of the body and gills
- Gradual or mass mortality
- Erosion of barbels, tail rot, body lesions
- Paleness and weight loss

Bacteria

Fish swimming in a vertical position at the water surface or exhibit abnormal swimming behavior may have bacterial disease. White spots or lesions on the skin, fins and mouth are also present. These are caused by bacteria such as *Aeromonas hydrophila*, *Pseudomonas*, and *Myxobacteria*.



FROM DISEASES OF CULTURED GROUPERS

Figure 15. Catfish with bacterial disease *(left)*; the parasite *Trichodina* spp.

Parasites

Parasites attach themselves to the skin, gills, digestive tract and various organs of the fish. The fish stays in a vertical position at the water surface or nervously rub their heads over the pond bottom. The skin is sometimes covered by a grayish white mucus film and the fish becomes pale. Gradual to mass mortality can occur. Examine the fish by scraping the tissues of gills or infected skins. Place the sample in a slide, add a drop of distilled water, cover with cover slip and analyze under the microscope. Some of the common parasites that attack catfishes are protozoans (*Chilodonella, Trichodina* spp., *Ichthyophthirius multifiliis*), trematodes (*Dactylogyrus, Gyrodactylus*) and leeches (*Hirudina*).

Figure 16. (*From top*) Fungal disease and broken head disease, a symptom of nutritional deficiency

Fungi

Infected catfish have cotton-like growth on the skin, mouth and barbels. The fungus especially occurs on skin injuries caused by handling or ectoparasites. Heavy infections result in abnormal swimming behavior and can cause mortality.

Nutrition

Nutritional diseases in catfish are brought about by feeding with farm-made food lacking in important nutrients and by using spoiled commercial pellet. Some unknown diseases suspected as nutritional causes are cracked or broken head disease, open belly disease, yellowish color, hemorrhage beneath the mouth, deformed bodies and loss of appetite.

Environment

Water contaminated by industrial and agricultural pollution or run-off, high or low water temperatures, and unfavorable environmental conditions will make catfish more vulnerable to diseases.

Disease prevention

- Acclimate properly and handle the fish carefully during harvest, transfer and stocking; as much as possible, avoid handling the fish to minimize stress
- Apply lime to pond water (5-10 ppm) biweekly or monthly; maintain the liming of the pond dikes
- Prevent the entry of insects and black bugs from rice fields into the cultured area to inhibit secondary infection of stocks
- Place sacks of ash or charcoal in pond corners for good water maintenance
- Use good quality feeds or trash fish
- Do not allow water to flow from one pond to another. Each pond should have its own inflow and outflow for easier water management
- Replenish water regularly
- Reduce pond water to a minimum depth of 8-10 cm and immerse catfish in saltwater (20-25 ppt) for 30-60 seconds biweekly or monthly. If seawater is not available, broadcast granulated table salt (20-25 g/L) into the pond, and immediately let in water up to the maximum depth. Draining and application of salt is done during the cooler parts of the day
- Improve skills in the detection of symptoms, prevention and treatment of diseases
- Submit live samples immediately to a fish health laboratory if a disease outbreak is suspected

ECONOMIC ANALYSIS

Economic evaluation is based on grow-out culture in a pond with an area of 1,000 m^2 (Table 4) using formulated diets; moist (chicken entrails or trash fish + rice bran); and a combination of pellet and moist at 50% composition each. Pond development and water pump are about 58% and 32% of the investment cost respectively, which are the major requirements (Table 5). Fingerlings and feeds are the major variable costs (Table 6.1, 7.1, 8.1). Farm gate average price of *Clarias macrocephalus* is is PhP130/kg, higher than that of other *Clarias* spp. because of its scarcity and more tender and delicious meat. The return-on-investment (ROI) and payback period range from 80%-122% and 0.8-1.2 years when using pellet, moist or a combination of these feeds (Table 6.2, 7.2, 8.2).

Feeding using formulated diet has an advantage of convenience in handling and storage. The quality required and quantity needed could be easily maintained. Total dry feed cost should not exceed 25% of the farm gate value of the cultured species. Although feeding catfish with moist diet gives acceptable results, using this could pose problems due to its inconsistent supply, storage requirements and its foul smell. It may be inexpensive and economical but the quantity and quality cannot be easily controlled. Daily feed acquisition and preparation are time-consuming, laborious and costly. Culturing catfish using moist diet is not recommended for commercial intensive production systems. However, in some localities with abundant supply, recycling these wastes as feed in small-scale or backyard ponds is highly recommended. This type of feed must be acquired in a cleaner, quicker handling and transport, stored well, then cooked before feeding.

Table 4. Technical assumptions

Assumptions	
Total pond area (m^2)	1,000
Target production (kg/crop)	770
Project duration (years)	5
Days of culture per crop	120
Number of crop per year	2
Total stock (pcs/crop)	10,000
Stocking density (pcs/m^2)	10
Average body weight at stocking (g)	3.0-5.0
Average body weight at harvest (g)	110
Feeding rate (% of body weight)	3.5-5.0
Feed cost (PhP/kg)	
Moist	7
Pellet	25
Survival rate (%)	70
Feed conversion ratio	2.3
Catfish price/kg (PhP)	130

Table 5. Investment requirements and depreciation for *C. macrocephalus*

Capital outlay	Value (PhP)	Economic life (yr)	Depreciation (PhP)	Salvage value (PhP)
Pond development	18,000	20	900	13,500
Water pump	10,000	10	1,000	5,000
Weighing scale	600	5	120	0
Pails, basins, scoop nets	300	5	60	0
Bolo, hammer, saw, spade	1,000	5	200	0
Seine	1,000	5	200	0
Total investment	30,900			
Depreciation/yr			2,480	
Depreciation/crop			1,240	
Salvage value after project duration				18,500

Table 6.1 Costs-and-returns analysis of *C. macrocephalus* grow-out using pellet feeds

Item	Quantity	Unit cost	Total cost
A. Revenue			
Catfish production (kg)	770	130	100,100
B. Operating cost			
1. Variable costs			
Fingerlings/ha/crop (pcs)	10,000	2	20,000
Feeds (kg)	1,771	25	44,275
Lime (kg)	100	1.5	150
Urea (kg)	2.5	17.8	45
16-20-0 (kg)	5	15.8	79
Cow or chicken manure (kg)	100	1.2	120
Fuel (for pumping)	50	36	1,800
Repair and maintenance (2% investment)			618
Miscellaneous expenses (2% revenue)			2,002
Subtotal			69,089
2. Fixed costs			
Family labor/crop (PhP)	19	200	3,800
Depreciation/crop			1,240
Interest rate/crop (50% bank loan; 12%/yr)			3,000
Subtotal			8,040
Total cost			77,128

Table 6.2 Economic indicators using pellet feeds

Net profit/crop	22,972
Return-on-investment (%)	80
Payback period (yr)	1.2
Break-even price (PhP)	100
Break-even production (kg)	593
Internal rate of return (IRR, %)	148%
Net present value (NPV)	129,655
Discounted benefit cost ratio (BCR)	6

Table 6.3 Sensitivity analysis scenarios using pellet feeds

1. Increase in feed cost by 20%	**Per crop**	**Per year**
Net profit (PhP/crop/year)	13,851.20	27,702.4
Return-on-investment (ROI, %)		50.8
Payback period (yr)		1.9
Break-even price (PhP)		112.0
Break-even production (kg)		663.5
NPV at 12%		70,944.9
IRR (%)		0.9
Discounted BCR		3.6
2. Decrease in selling price of catfish by 20%		
Net profit (PhP/crop/year)	3,293.26	6,586.53
Return-on-investment (ROI, %)		16.67
Payback period (yr)		5.35
Break-even price (PhP)		111.72
Break-even production (kg)		742
NPV at 12%		2,982.45
IRR (%)		15.41%
Discounted BCR		1.11
3. Survival of 55%		
Net profit (PhP/crop/year)	11,736	23,471.68
Return-on-investment (ROI, %)		44
Payback period (yr)		2.2
Break-even price (PhP)		111
Break-even production (kg)		515
NPV at 12%		57,328
IRR (%)		74%
Discounted BCR		3

Table 7.1 Costs-and-returns analysis of *C. macrocephalus* grow-out using moist feeds

Item	Quantity	Unit cost	Total cost
A. Revenue			
Catfish production (kg)	770	130	100,100
B. Operating cost			
1. Variable costs			
Fingerlings/ha/crop (pcs)	10,000	2	20,000
Feeds (kg)	3,542	9	31,878
Lime (kg)	100	1.5	150
Urea (kg)	2.5	17.8	45
16-20-0 (kg)	5	15.8	79
Cow or chicken manure (kg)	100	1.2	120
Fuel (for pumping)	50	36	1,800
Repair and maintenance (2% investment)			618
Miscellaneous expenses (2% revenue)			2,002
Subtotal			56,692
2. Fixed costs			
Family labor/crop (PhP)	19	200	3,800
Depreciation/crop			1,240
Interest rate/crop (50% bank loan; 12%/yr)			2,628
Sub-total			7,668
Total cost			**64,359**

Table 7.2 Economic indicators using moist feeds

Net profit/crop	35,741
Return-on-investment (%)	122
Payback period (yr)	0.8
Break-even price (PhP)	84
Break-even production (kg)	495
NPV at 12%	211,850
Internal rate of return (IRR, %)	231%
Discounted BCR	9

Table 7.3 Sensitivity analysis scenarios using moist feeds

1. Increase in feed cost by 20%	**Per crop**	**Per year**
Net profit (PhP/crop/year)	29,173.89	58,347.77
Return-on-investment (ROI, %)		100.43
Payback period (yr)		0.98
Break-even price (PhP)		92.11
Break-even production (kg)		546
NPV at 12%		169,578.63
IRR (%)		188.45%
Discounted BCR		7.15
2. Decrease in selling price of catfish by 20%		
Net profit (PhP/crop/year)	18,615.96	37,231.91
Return-on-investment (ROI, %)		66.26
Payback period (yr)		1.46
Break-even price (PhP)		91.82
Break-even production (kg)		610
NPV at 12%		101,616.16
IRR (%)		119.53%
Discounted BCR		4.68
3. Survival of 75%		
Net profit (PhP/crop/year)	21,769	43,537
Return-on-investment (ROI, %)		76
Payback period (yr)		1.3
Break-even price (PhP)		94
Break-even production (kg)		438
NPV at 12%		121,910
IRR (%)		140%
Discounted BCR		5

Table 8.1 Costs-and-returns analysis of *C. macrocephalus* grow-out using 50% pellet and 50% moist feeds

Item	Quantity	Unit cost	Total cost
A. Revenue			
Catfish production (kg)	770	130	100,100
B. Operating cost			
1. Variable costs			
Fingerlings/ha/crop (pcs)	10,000	2	20,000
Feeds (kg)			
Pellet	886	25	22,138
Moist	1,771	9	15,939
Lime (kg)	100	1.5	150
Urea (kg)	2.5	17.8	45
16-20-0 (kg)	5	15.8	79
Cow or chicken manure (kg)	100	1.2	120
Fuel (for pumping)	50	36	1,800
Repair and maintenance (2% investment)			618
Miscellaneous expenses (2% revenue)			2,002
Subtotal			62,890
2. Fixed costs			
Family labor/crop (PhP)	19	200	3,800
Depreciation/crop			1,240
Interest rate/crop (50% bank loan; 12%/yr)			2,814
Subtotal			7,854
Total cost			70,744

Table 8.2 Economic indicators using 50% pellet and 50% moist feeds

Net profit/crop	29,356
Return-on-investment (%)	101
Payback period (yr)	1.0
Break-even price (PhP)	92
Break-even production (kg)	544
IRR (%)	190%
NPV at 12%	170,753
Discounted BCR	7

Table 8.3. Sensitivity analysis scenarios using 50% pellet and 50% moist feeds

1. Increase in feed cost by 20%	**Per crop**	**Per year**
Net profit (PhP/crop/year)	21,512.54	43,025.08
Return-on-investment (ROI, %)		75.63
Payback period (yr)		1.29
Break-even price (PhP)		102.06
Break-even production (kg)		605
NPV at 12%		120,261.78
IRR (%)		138.51%
Discounted BCR		5.36
2. Decrease in selling price of catfish by 20%		
Net profit (PhP/crop/year)	10,954.61	21,909.22
Return-on-investment (ROI, %)		41.46
Payback period (yr)		2.30
Break-even price (PhP)		101.77
Break-even production (kg)		676
NPV at 12%		52,299.31
IRR (%)		68.73%
Discounted BCR		2.90
3. Survival of 75%		
Net profit (PhP/crop/year)	16,752	33,504.40
Return-on-investment (ROI, %)		60
Payback period (yr)		1.6
Break-even price (PhP)		102
Break-even production (kg)		476
NPV at 12%		89,619
IRR (%)		107%
Discounted BCR		4

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- The Marine Fisheries Research Department (MFRD) in Singapore (1967) for post-harvest technologies
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- The Marine Fishery Resources Development and Management Department (MFRDMD) in Kuala Terengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries

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- Produce, disseminate and exchange aquaculture information

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